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ABSTRACT

The main objective of this exploratory investigation was to gather some evidence to support the notion that students can use science learnings interpretively, with respect to current relevant life problems. The students involved were non-science majors (N=138) enrolled in a physical science course. Data were collected at the beginning of the course with respect to awareness, knowledge, and interest in environmental problems so that this information could be used by the instructor to develop background materials for the course. Students were given an instrument consisting of four briefly-stated possible environmental catastrophes and asked to interpret the meaning of each catastrophe, and specify information needed or questions they would like to ask about each predicted catastrophe. Results of the background survey revealed the students to be very much aware of the current environmental problems. Among the major findings from the catastrophe instrument were: (1) over 65 percent of the students were able to successfully interpret at least one or more of the four catastrophes; (2) eight students' interpretations challenged the validity of the predicted catastrophes and presented reasons for the challenge; and (3) misconceptions generally centered around reactions involved and the properties of such substances as carbon dioxide and mercury. (Author/PEB)

An Analysis of College Students' Interpretations of Some Possible Environmental Catastrophes

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of the National Association for
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Introduction

Teaching science content that has real world relevancy is one objective that science educators are usually striving to attain. Scientific literacy, especially with respect to the understanding and the interpretation of real problems of the everyday world, is a most worthy goal of all science teaching.

Broudy[2] contends that teaching science as it is used in life situations would guarantee relevance but more research is needed in "the way that science study as a school input functions when confronted by nonschool situations, especially such societal situations as the quality of the environment". He strongly suggests that more research is needed on "the way school learnings are used interpretively to build the conceptical contexts in which the nature of life problems become intelligible." Answers to these research questions Broudy asserts, will provide to the study of science a rationale that can withstand the current attacks directed against science.

In very recent years textbook and curriculum writers have worked on providing materials to establish some form of environmental education for all youth from elementary to college age. The news and communication media have done an outstanding job of making the public more aware of many of the current environmental problems. This would strongly suggest that a scientific literacy is necessary in order to better understand and interpret current environmental problems. New science courses become necessary; these new courses should be centered upon our societal problems.

Purpose

The main general objective of this exploratory investigation is to gather some evidence to support the notion that students can use science learnings interpretively, with respect to current relevant life problems.

More specifically, the study was designed to analyze college students' (non-science majors) interpretations of some possible environmental catastrophes. The research was guided by focusing on these questions:

1. Can college non-science majors interpret some predicted environmental catastrophes with respect to using past school science learnings? What is the cognitive level of these interpretations?
2. What are the science misconceptions that non-science majors have with respect to interpreting these problems?
3. Can the students demonstrate and suggest the needed science background that could be used to provide the basis for a physical science course centered on the environmental problems?

Procedure

The student sample used in this investigation consisted of 138 non-science majors enrolled in a physical science course. The data was collected at the beginning of the course with the hope that the results could help the instructor develop some background materials for the course. On the first day of lecture, a survey form designed to assess the general background of the students with respect to awareness, knowledge, and interest in environmental problems was distributed. (See Appendix A.)

In the next lecture session, an information gathering instrument was distributed to the students. This consisted of four briefly stated possible environmental catastrophes as predicted by environmental writers.[4] The students were next instructed to respond to each of the four proposed catastrophes in the following manner:

1. Please interpret in your own words the meaning of each predicted environmental catastrophe.
2. State any possible solutions that you think might be feasible in preventing the catastrophe.
3. If you feel that you need more background information or if you feel that you need to ask some questions about the predicted statement, what general or specific information would you like to know more about. (See Appendix B)

The science concepts that could be used to interpret the four proposed catastrophes were independently written by three competent university chemistry professors. A brief composite summary of these science concepts was constructed and verified by the consultation of several references.[4,6,7] This was used by the researcher in the analyses of the students' written protocols. (See Appendix C.)

Data Analyses

In analyzing the students' responses to the three statements above, a reasonably systematic format was used.

For statement 1, which included responses relating to interpretations, a brief condensed version of a cognitive taxonomy was developed. This taxonomy is based in part on the original work of Bloom.[1] The three-stage hierarchy consisted of: I. Knowledge, II. Comprehension, III. Application and/or Evaluation. (See Appendix D)

For statement 2, an open system of categorizing the types or general areas of the solutions suggested by the students was used. The overall common categories that evolved are discussed in the findings.

For statement 3, which requested the students' to propose questions about the need for more background, a three category taxonomy was developed. This taxonomy was suggested to the researcher with reference to the work done by Huston.[5] Huston's work categorized value preferences or value orientations of chemistry students. The three category taxonomy used was: Theoretical, Humanistic, and Technological. (See Appendix E)

Discussion of Findings

The results of the background information survey (See Appendix A) revealed that beginning college students are very much aware of the current environmental problems. The background comes from both the communication media and formal education. Television and newspapers are the two greatest informal sources of information. High school biology and high school social studies classes provided the most students with a formal knowledge of the problem, although other high school science courses, chemistry, earth science, physics, did provide some knowledge. The older college students who had other college courses such as biology, geography, physical science I also indicated some background information coming from these sources. Seventy-nine percent of the students preferred to take a physical science course centered on environment problems rather than the conventional course. This survey strongly indicated that college students are aware of and very much interested in current environmental problems.

The student responses to statement 1 on interpretations of the four environmental problems are listed in Appendix F. The highest entries were usually categorized under the Knowledge criteria. However with reference to Catastrophe A which relates to the potential disruption of the CO_2 balance with the subsequent warming of the earth, the students' responses were found to be 18.1% in Knowledge category, 51.2% in the Comprehension category and 25.2% in the Application/Evaluation category. The Catastrophe D, which concerns the SST exhaust depleting our stratospheric ozone layer, appeared most difficult for the students as only 18.1% and 8.5% of the responses were in the higher level II and level III categories of the taxonomy.

The researcher decided to score a successful interpretation of the phenomena as those interpretations which were categorized under level II Comprehension and level III Application/Evaluation. The results were Catastrophe A, 76.4%; B, 48.8%; C, 52.9%; D, 26.6%; with an overall success score of 245 out of 463 attempts for 52.9% successful interpretations. These findings lend a partial answer to the research question stated on page 2. College students can interpret environmental problems with respect to using past school science learnings and their interpretations are generally of a higher cognitive order level II and level III. However, there still exists a need for improving their awareness and knowledge in order to develop a higher order of cognitive functioning with respect to our environmental problems.

A summary of the students' solutions to the predicted catastrophe are listed in Appendix G. The greatest number of solutions were categorized under the use of Alternate Methods. This was followed by Industry, Stop Current Sources and Government. Since a great number of solutions centered on Alternate Methods or Processes, a better and deeper knowledge of potential pollution processes is necessary. This would also suggest adding information about these processes to the current physical science course.

The students' responses with respect to their questions for more background information was found to be:

	Number	Percent of Total
Theoretical		
1. Facts, Terms, etc.	227	29.4%
2. Conceptual, Reactions, Processes	307	39.8%
Humanistic	171	22.1%
Technological	67	8.7%

These results suggest the need for more background on the theoretical aspects of the environmental problems since 69% of all the questions requesting background were theoretically oriented. These findings also indicate the need to relate science learnings to the humanistic side of the current environmental problems.

An attempt was made to categorize possible science misconceptions. Doran[3] surveyed several studies which described ways of classifying misconceptions. This researcher was unable to use any formal methods of classifying misconceptions except that misconceptions were only noted if a direct contradiction of a fact or a concept was stated by a student in his interpretations. Some students' responses were classified under Knowledge or Comprehension, but since only part of the output indicated a misconception they were also categorized as a misconception. The following is a summary of the misconceptions: Catastrophe A, 12; B, 3; C, 3; and D, 7. The misconceptions generally centered around the reactions involved and the specific properties of substances such as carbon dioxide in Catastrophe A; mercury in Catastrophe C; and ozone, nitric oxide, and the nature of ultraviolet radiation mentioned in Catastrophe D. The awareness of these specific kinds of misconceptions can be used by instructors as a diagnostic tool. Instructors can spend time on lecture topics to specifically correct these misconceptions.

An exhaustive list of the science terms or science vocabulary used by the students in their interpretations was tabulated. Of particular interest to this researcher was the use of "new" science terms. These are terms that the student introduced into his interpretations that come from previous science learnings. The use of such terms as "greenhouse effect," balance of nature, fossil fuels, food chain, cause and effect, entropy changes, hydrologic cycle, sewage treatment plants, are indicative of previous science learnings being used in a higher order of cognitive functioning (level II or level III).

The researcher noted that about eight students' interpretations challenged the validity of the predicted catastrophes. Some presented reasons for their challenge, while others demanded quantitative data or trends to substantiate the predicted catastrophes. A few students questioned the time variable which was not mentioned in the catastrophe statements. The challenging interpretations made by these students demonstrate a very high order of cognitive functioning (level III). They also serve to further substantiate the notion that previous science learnings can be critically used by non-science majors to interpret current environment problems. This researcher would certainly hope that more students would use this critical challenging approach in their interpretations.

The results of this exploratory study have provided some answers to the research questions stated earlier in this paper. The findings have also enabled this researcher to institute into the physical science course a new theme based upon current environmental problems. Although the students clearly demonstrated that previous school science learnings can be used to interpret relevant environmental problems, this physical science course can hope to strengthen and deepen their background and hopefully allow them to interpret on a much higher cognitive level.

Significance and Suggestions for Further Research

The type of analyses used in this investigation which involved the free written output of students has limitations with respect to the possible use of traditional statistical inferences. The classification system used served as a possible way of objectively looking at the data. These categories seem reliable enough to use again in replication type of studies. This type of analyses is closer to the real world and the real behavior of people when they are responding to relevant problems. Analyses of free written output are valuable in that they can provide research data upon which to build more definitive and objective evaluation instruments.

The findings of this study have already provided this researcher with some data to develop an instrument to assess attitudes or value orientations towards environmental problems. Other areas of research might include the analysis of the spontaneous verbal interpretations of an individual or of a small group. Other areas of further research suggested by this study can be centered on these questions: Can science misconceptions with respect to environmental problems be categorized? Can an objective type of evaluation instrument be constructed that would assess the cognitive level of functioning with respect to the interpretations of environmental problems?

Appendix A

Survey Form of Background Information
(Summary of Student Data Included)

I. Please check those sources below from which you gained some knowledge about our current environmental problems, such as air and water pollution, energy crisis, etc.

127 Television

37 Radio

36 Journals, magazines

60 Newspapers

35 Discussions with friends, family, etc.

II. From those that you have checked above, please indicate your two most important sources of information:

Television first

Newspapers second

III. From your formal education, check those that provided you with some knowledge and some background about environmental problems.

88 High school biology classes
49 High school chemistry classes
44 High school earth science classes
36 High school physics
84 High school social studies classes, P.O.D., etc.

____ Other high school classes such as ____

14 College courses such as World Geography, Science 105

12 Science Club Activities

IV. If you were given a choice of taking one of the following required lab-science courses, which one would you select?

(28) 20.3% Physical Science II (Conventional topics, chemistry, geology, etc.)

(110) 79.7% Physical Science II (Theme is centered on Current Environmental problems)

Appendix B

Information Gathering Instrument

Environmental writers of the past decade have forecast an assortment of catastrophes, including:

A. A hot earth, new deserts, melted ice caps, and flooded coastal cities - all due to the billions of tons of carbon dioxide released into the air each year by man's enterprise.

B. An atmosphere running out of oxygen because of pollution's threat to the microscopic, ocean-dwelling phytoplankton, a primary source of oxygen on this planet.

C. Oceans filling with toxic mercury, washed to sea by the cesspool rivers from cities around the world.

D. A stratosphere no longer shielding man from deadly ultraviolet light because of the depletion of its protective ozone screen by nitric oxide exhaust from high-flying SST aircraft.

For each of the above four statements, please respond according to these 3 questions. Please use the lined paper provided by your instructor.

1. Please interpret in your own words the meaning of each predicted environmental catastrophe.

2. State any possible solutions that you think might be feasible in preventing THE CATASTROPHE.

3. If you feel that you need more background information or if you feel that you need to ask some questions about the predicted statement, what general or specific information would you like to know more about?

Appendix C

Scientific Concepts, Principles and Ideas Behind the Forecasted Environmental Catastrophes

A. Civilized man with his technological, industrial, advances has been adding billion of tons of CO_2 into the atmosphere. The increased CO_2 along with the water vapor in the atmosphere will absorb the earth's radiating heat. The earth radiates heat away in the infrared region of the electro-magnetic spectra. The molecules of CO_2 and H_2O both have infrared absorption bands and as a result will absorb this heat (IR) and keep it in the atmosphere. This is analogous to the "greenhouse effect" or the "hot-house effect". The increase in the average temperature of the atmosphere can cause long-term effects on the climate with subsequent melting of polar ice caps and flooding coastal cities.

B. Approximately 50-80% of the world's photosynthesis occurs in the oceans. It is mainly carried out by phytoplankton - microscopic marine plants. These plants are considered a good primary source of oxygen on this planet. These plants however are highly susceptible to chemical poisoning. Such pesticides as DDT and the heavy metal pollutants such as mercury and lead in a few parts per billion can reduce the photosynthesis process. The respiration and/or decay - photosynthesis cycle can therefore be disrupted and as a result perhaps the oxygen in the atmosphere would be reduced by plant and animal respiration and decay and modern man's tremendous industrial need for oxygen in many industrial processes.

Appendix C (continued)

C. The heavy-metal mercury is used in many industrial processes. The chloro-alkali industry is one of the largest users. Other sources include pulp and paper industry, seed dressings, paints, disinfectants. The combustion of fuels can also add Hg to environment. In recent years more and more mercury has worked its way to large bodies of water. Mercury has been changed by microorganisms into a methylated form. This methylated mercury can be incorporated into living things. By biological concentrated and followed by biological (food-chain) magnification it can become very toxic to man who may eat sea-food.

D. Ozone (O_3) exists in the stratosphere about 10-25 miles above the earth. The ozone absorbs some of the deadly ultraviolet radiation coming from the sun and as a result protects some living organisms from being damaged by this U-V radiation. The high-flying super sonic transports emit nitric oxide (NO) in their exhaust. The NO reacts rapidly with ozone to form nitrogen dioxide which subsequently reacts with atomic oxygen to produce more NO. This cyclic reaction will continue until it eventually depletes the ozone layer.

Appendix D

Taxonomy of Students' Responses to Predicted Environmental Catastrophes

I. Knowledge - This includes statements of simple recall, recognition of facts or terms. Some new paraphrased terms are used. Simple agreement with the content of the predicted statement may imply some recognition.

II. Comprehension - This includes knowledge of some terms, facts, concepts and the translation into other terms or forms as well as some possible interpretations such as inferences, generalizations or summarizations. This may also include some inferences, estimates, or predictions with respect to consequences of the environmental catastrophe.

III. Application and/or Evaluation - This is the highest order of cognitive functioning and includes the above knowledge and comprehension along with the relating or the applying of the concepts to other broad experiences. The application may involve some qualitative or quantitative judgments about the value of the predicted situation. The values stated or implied may be those of the individual student or of society.

Appendix E

Taxonomy of Students' Responses with Reference to Students' Questions

A. <u>Theoretical</u>: Questions that wanted or desired information relating to:

a. Facts, terms, specific types, properties

b. Concepts, principles, reactions, processes, rates of reactions

B. <u>Humanistic</u>: Questions that refer to the individual, to man, to society, to governments and politics, to world effects, and to global uses and applications.

C. <u>Technological</u>: Questions that desire information about industry, about technology in general, about the automobile, about business, and capital.

Appendix F

Summary of Students' Interpretations of Catastrophes

Catastrophe	No. Attempted	Knowledge	Comprehension	Application Evaluation	Unable to Classify
A	127	23 (18.1%)	65 (51.2%)	32 (25.2%)	7 (5.5%)
B	123	57 (46.3%)	46 (37.4%)	14 (11.4%)	6 (4.9%)
C	119	51 (42.8%)	43 (36.1%)	20 (16.8%)	5 (4.2%)
D	94	58 (61.7%)	17 (18.1%)	8 (8.5%)	11 (11.7%)

Appendix G

Summary of the Most Common Solutions Suggested by Students

1. Alternate Methods - Solution involves use of new processes, new or different products or recycling methods. 190
2. Industry - Make industry stop, or change; put tax on industry. 101
3. Stop Current Sources of Pollution - Slow down, lessen or cut-down the processes at the source. 100
4. Government - U.S. and/or world governments must enforce pollution controls. 82
5. Human Nature - Emphasis is pessimistic. Personal greed, selfishness of individuals and society must change. 43
6. Automobiles - Stop or cut down on automobile emissions and/or use. 21
7. More Education - Necessary in order to better understand problems. 17

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